

# HOMES

## QUICK FACTS

The most common high-dose source of lead in the United States is leaded paint in old homes, especially those built before 1950 and in poor condition.<sup>1</sup>

Secondhand smoke contains at least 250 chemicals known to impact human health,<sup>2</sup> including more than 50 that are known to cause cancer.<sup>3</sup> For children, home is the dominant site of exposure.<sup>3</sup>

The U.S. Surgeon General issued a Health Advisory in 2005 warning Americans about the serious health risk from exposure to radon in indoor air. Radon is the second leading cause of lung cancer after smoking. Currently, the EPA estimates that 21,000 lung cancer deaths each year in the United States are radon-related.<sup>4</sup>

In 2000, the EPA estimated that 75% of U.S. households used at least one pesticide indoors during the past year and that 80% of most people's exposure to pesticides occurred indoors.<sup>5</sup>

*Research suggests that people spend 90% of their time indoors, making the indoor environment a significant factor for a number of health effects. Though rarely monitored, poor indoor air quality and exposures to hazardous substances in the home are preventable.<sup>6</sup>*

## INTRODUCTION

Most people spend the majority of time inside their homes, where concentrations of pollutants and irritants can be much higher than in outside air.<sup>6</sup> Indoor pollutants include biologic contaminants, organic chemicals from household products, and naturally occurring hazards, such as radon. In addition, outdoor air pollutants make their way into the home and can at times become more concentrated because of inadequate ventilation and a lack of air circulation between the inside and outside environments. To reduce indoor air pollution, a good supply of fresh outdoor air is needed. The movement of air into and out of the home is very important. This air helps reduce the level of pollutants indoors.<sup>7</sup> High temperature and humidity levels can also increase concentrations of some pollutants.<sup>8</sup>



This module presents a sampling of what we know about select indoor pollutants and their related health effects. Much remains to be done before we have a complete picture of the environmental health risks encountered in our homes, but exposures to the following indoor hazards are known to cause or have been linked to adverse health effects, such as cancer, asthma, and poisoning<sup>9</sup>:

- Lead
- Secondhand tobacco smoke
- Radon
- Aeroallergens
- Pesticides
- Volatile organic compounds

Carbon monoxide poisoning is an important home health hazard. This topic is addressed in the Poisoning module.

## HOW ARE WE TRACKING EXPOSURES IN THE HOME?

Indoor air quality—especially in homes—is not monitored, and this lack of monitoring accounts for a large gap in our knowledge of environmental exposures that occur in indoor spaces. As a result, when it comes to indoor hazards, we must rely on individual studies or limited surveys to estimate exposures to contaminants in the home.

For some of the exposures discussed below, public health officials rely on biomonitoring to measure the body burden of exposures. Biomonitoring data tells us only that someone has been exposed to a compound of concern, not where, how, or for how long the exposure might have occurred.

## LEAD

### WHAT IS LEAD?

Lead is a soft, malleable, metallic element that can be found in such household items as pipes, paint, ceramic glazes, cosmetics, medicines, and toys.<sup>10</sup> Today, lead is still used in many products and is released into the air through combustion of coals and oil and through waste incineration. In addition, lead may be present in products imported to the United States from countries that do not limit its use.



Until the late 1970s, lead was a component of many residential paints. Before 1950, lead was commonly used in house paint and could be present in high concentrations. Awareness of the adverse health effects of lead-based paint resulted in U.S. regulation of the lead content in new paint for residences. The concentration of lead in paint was gradually reduced between 1950 and 1978. In 1978, lead in new residential paint was limited to 600 parts per million (ppm).<sup>11</sup> In April 2009, lead was limited to 300 ppm, and the Consumer Product Safety Commission (CPSC) is considering lowering the lead content even more. Today, homes built before 1978 remain the major source of lead exposure for young children; homes built before 1950 constitute a greater threat.<sup>12</sup>

Lead-contaminated drinking water is most often a problem in houses that are either very old or very new. Through the early 1900s, it was common practice in some areas of the country to use lead pipes for interior plumbing. Also, lead piping was often used for the service connections that join residences to public water supplies. This practice ended only recently in some localities. Plumbing installed before 1930 is most likely to contain lead. Copper pipes have replaced lead pipes in most residential plumbing. However, the use of lead solder with copper pipes is widespread. Experts regard this lead solder as the major cause of lead contamination of household water in U.S. homes today. New brass faucets and fittings can also leach lead even though they are “lead-free”. Scientific data indicate that the newer the home, the greater the risk of lead contamination. Lead levels decrease as a building ages. This is because, as time passes, mineral deposits form a coating on the inside of the pipes (if the water is not corrosive). This coating insulates the water from the solder. But, during the first five years (before the coating forms) water is in direct contact with the lead. More likely than not, water in buildings less than five years old has high levels of lead contamination.<sup>13</sup>

## WHAT ARE THE HEALTH EFFECTS OF LEAD EXPOSURE?

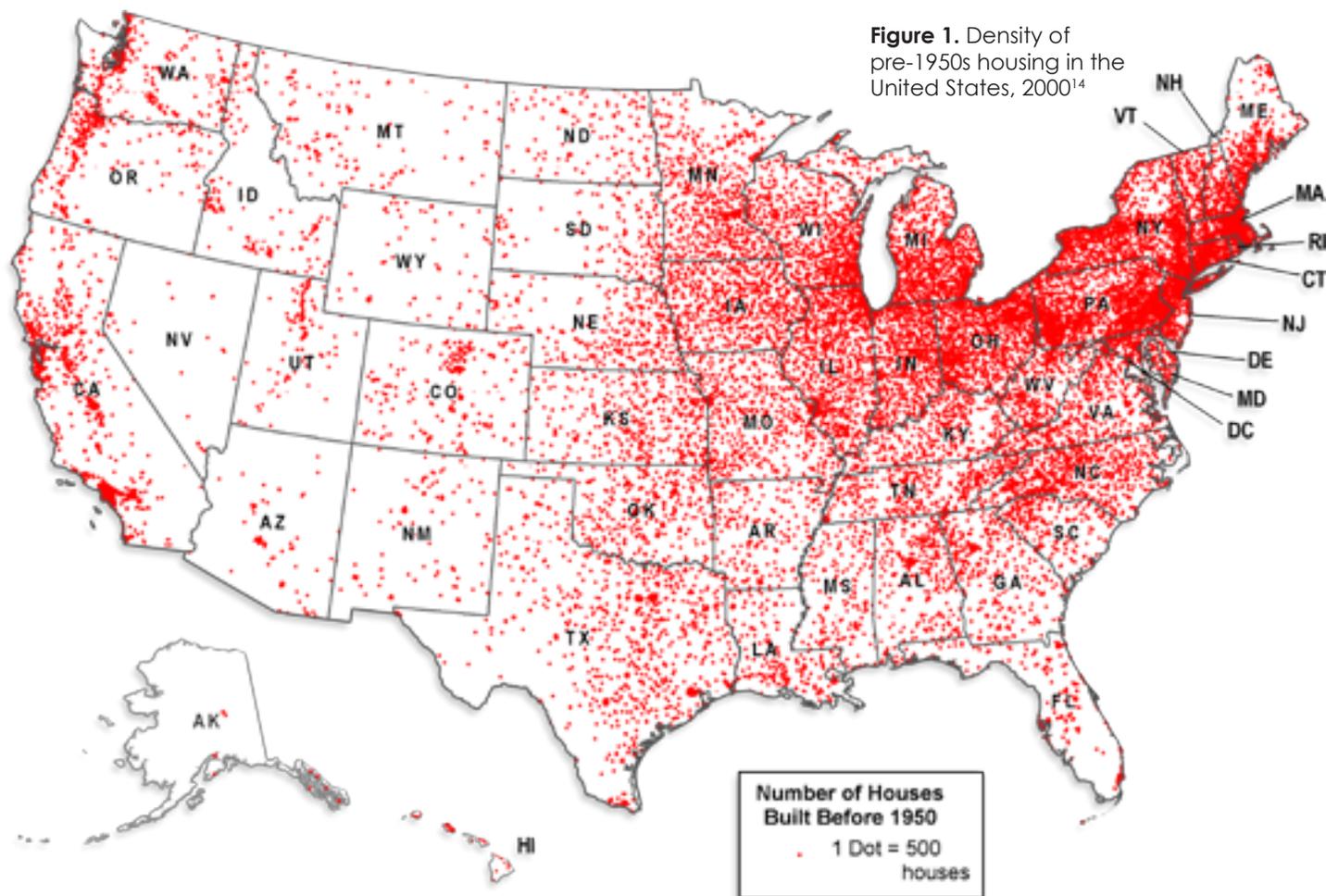
Lead has been extensively studied and linked with numerous health problems, including iron deficiency anemia, severe stomachache, muscle weakness, and learning and behavioral difficulties. Very high concentrations of lead in the blood can cause seizures, coma, and death (*see Lead Poisoning module*).

## HOW ARE WE TRACKING LEAD EXPOSURE IN THE HOME?

The chapter on lead poisoning discusses how we rely on blood monitoring data to measure levels of lead in children. Environmental testing and other sources of data are used to estimate the number of homes in the United States that might contain unsafe levels of lead. U.S. Census data of homes constructed prior to 1950, when leaded paint was commonly used, can pinpoint—to the neighborhood level—the houses that might present a lead hazard due to paint.

The National Survey of Lead and Allergens in Housing (NSLAH), conducted from 1998–2000, is a nationally representative sample of 831 homes in 75 metropolitan areas that underwent extensive testing for lead. Results of NSLAH were extrapolated across the United States to generate national estimates of the types of lead risks in homes.

Exposure to lead from drinking water is estimated using water monitoring samples from community water systems and private wells. Under the authority of the Safe Drinking Water Act, the Environmental Protection Agency (EPA) set the action level for lead in drinking water at 15 parts per billion (ppb). This means utilities must ensure that water from the customer’s tap does not exceed this level in at least 90% of the homes sampled. If water from the tap does exceed this limit, then the utility must take certain steps to correct the problem. Utilities must also notify citizens of all violations of the standard. If you receive drinking water from a public water supplier, you receive an annual Consumer Confidence Report. Check the report for results of testing for your water supply. Typically, lead gets into your water after the water leaves your local treatment plant or your well. That is, the source of lead in your home’s water is most likely pipe or solder in your home’s own plumbing. The most common cause is corrosion, a reaction between the water and the lead pipes or solder. Dissolved oxygen, low pH (acidity) and low mineral content in water are common causes of corrosion.<sup>13</sup>



## WHAT ARE THE STATUS AND TRENDS FOR LEAD EXPOSURE

The most common high-dose source of lead in the United States is leaded paint in old homes, especially those built before 1950 (Figure 1). Approximately 40% of U.S. housing units (38 million) contain lead-based paint, and, of those, 24 million have significant lead-based paint hazards in the form of deteriorated lead-based paint, lead-contaminated house dust, and lead-contaminated bare soil.<sup>1</sup>

The highest density of pre-1950s housing occurs east of the Mississippi River and along the west coast (Figure 1). This correlates fairly well with the prevalence of elevated blood lead levels in children (Figure 2). In New York State, which has the most pre-1950s housing units of all the states, 42% of dwellings were built before 1950.<sup>14</sup>

Drinking water is also a potential source of lead exposure. Lead pipes, lead solder, and brass fixtures in household plumbing can leach lead into home water supplies. Infants who drink formula made with lead-contaminated water could be at risk of elevated blood lead levels.<sup>16</sup> The EPA estimates that approximately 40 million U.S. residents are exposed to lead concentrations in drinking water exceeding EPA's "action level" for lead (15 ppb). In Pennsylvania, a statewide survey of private water supplies (homes using groundwater or springs) revealed that about 20% had lead concentrations greater than 15 ppb.<sup>17</sup>

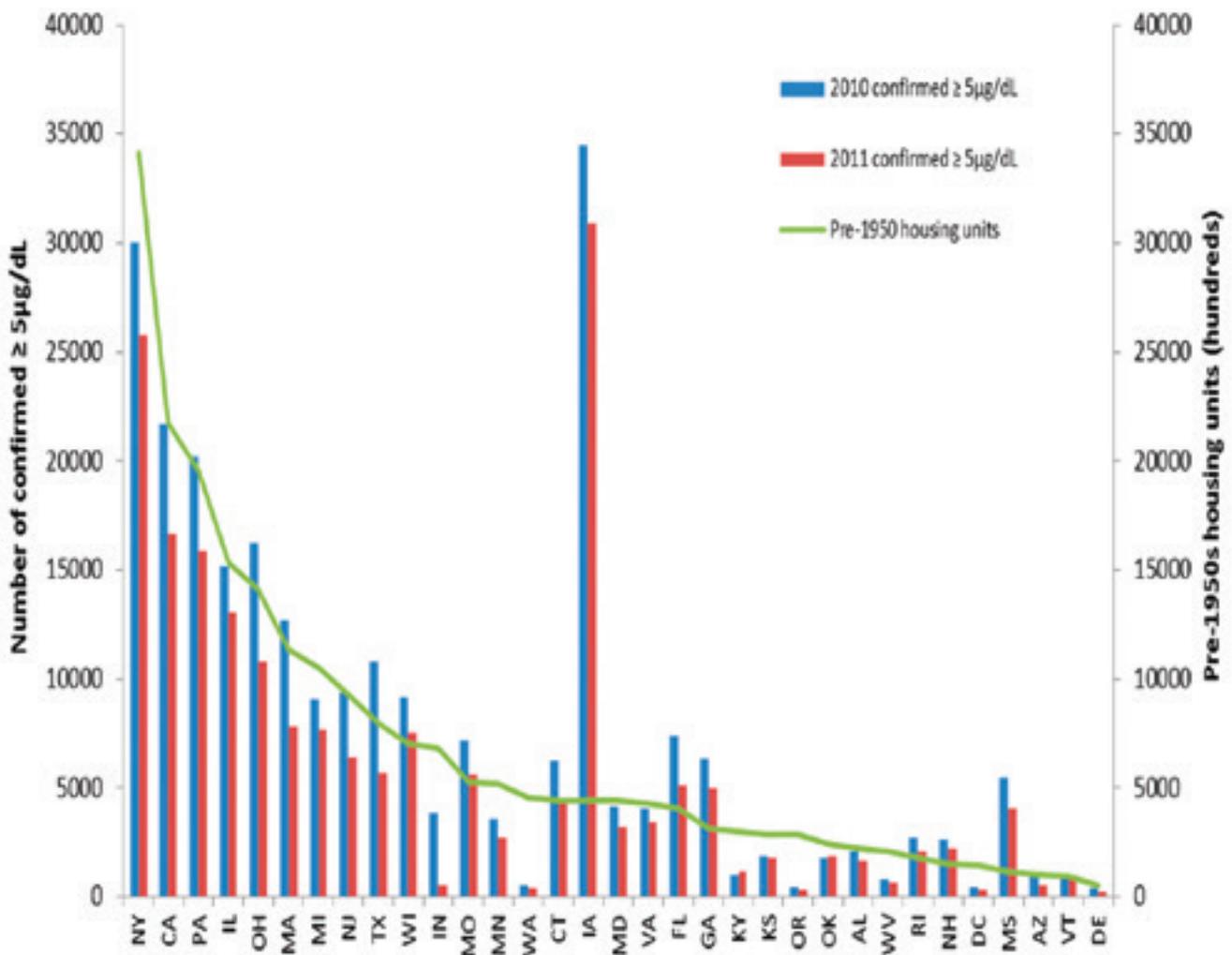
Recently, many imported toys have been found to violate the federal lead paint standard, prompting dozens of recalls. The U.S. Consumer Product Safety Commission issued 48 recalls for toys in 2007 because the toys contained too much lead. Many of the recalls involved more than one type of toy, and tens to thousands of each toy type were imported. In total, more than 6 million toys were recalled in 2007 because they posed a lead health risk.<sup>18</sup>

## HOW CAN LEAD POISONING BE PREVENTED?

Lead poisoning is entirely preventable. The key is stopping children from coming into contact with lead. The major source of lead exposure among U.S. children is lead-based paint and lead-contaminated dust found in deteriorating buildings. For more information on minimizing your family's risk of lead poisoning, see the Prevention section of the Lead Poisoning module.

## ADDITIONAL RESOURCES

- CDC web page on Lead [www.cdc.gov/nceh/lead](http://www.cdc.gov/nceh/lead)
- EPA [www.epa.gov/lead/index.html](http://www.epa.gov/lead/index.html)
- U. S. Consumer Products Safety Commission (CPSC) [www.cpsc.gov](http://www.cpsc.gov)



**Figure 2.** Number of pre-1950s housing units and children with confirmed blood lead levels greater than or equal to 5 micrograms per deciliter ( $\mu\text{g/dL}$ ) in the United States, 2012<sup>14,15</sup>

## SECONDHAND TOBACCO SMOKE

### WHAT IS SECONDHAND TOBACCO SMOKE?

Secondhand tobacco smoke, also called environmental tobacco smoke (ETS), is a complex mixture of gases and particles given off by burning cigarettes, pipes, cigars and the smoke exhaled by smokers.<sup>2</sup> Secondhand smoke contains more than 4,000 chemicals, many of which are toxic and cause cancer. At least 250 chemicals are known to impact human health,<sup>2</sup> including more than 50 that can cause cancer.<sup>3</sup>

Exposure to secondhand smoke occurs primarily in enclosed places, such as homes, cars, malls, restaurants, and bars. For children, home is the dominant site of exposure, but the workplace can be the site of greatest exposure for some adults.<sup>3</sup> Gradually, cities, counties, and states are joining the movement to restrict smoking in public, businesses are becoming smoke-free, and more people are prohibiting smoking in their homes. Nonetheless, children who live in homes with smokers remain unprotected.

### WHAT ARE THE HEALTH EFFECTS OF EXPOSURE TO SECONDHAND TOBACCO SMOKE?

The U.S. Surgeon General has concluded that secondhand smoke exposure causes premature death and disease in children and nonsmoking adults and causes heart disease and lung cancer in nonsmoking adults. Breathing secondhand smoke, even in small amounts, is dangerous to human health and can cause lung cancer and an increased risk of heart disease, specifically heart attack, in adult non-smokers. Secondhand smoke irritates the skin, eyes, nose, and throat and is particularly harmful to individuals with allergies and breathing problems.<sup>3</sup> Breathing secondhand smoke interferes with the function of the heart, blood, and vascular system. Secondhand smoke exposure has also been associated with a number of health problems in infants and children, including sudden infant death syndrome (SIDS), acute respiratory infections, middle ear disease, more severe asthma, respiratory symptoms, and slowed lung growth.<sup>3</sup> In addition, a 2010 study shows that children exposed to secondhand smoke, particularly between 8 to 13 years of age, face a higher risk of developing the early signs of clogged arteries by the time they are 13 years old.<sup>20</sup>

## HOW ARE WE TRACKING EXPOSURE TO SECONDHAND SMOKE IN THE HOME?

Data on levels of secondhand smoke in indoor areas are derived from individual studies and cannot be extrapolated to provide estimates across the United States. Therefore, we rely on surveys about smoking behavior and CDC's national biomonitoring program\* to estimate exposure to secondhand smoke. Comparisons of these two show that measurements of cotinine, a major metabolite of nicotine, predict a much larger number of people exposed to secondhand smoke than do survey questions.<sup>3</sup>

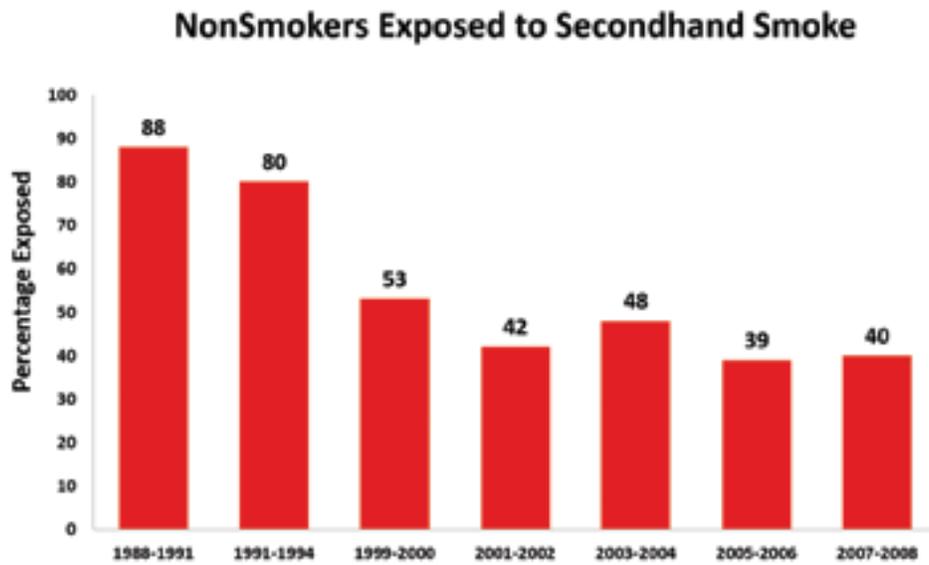
### WHAT ARE THE STATUS AND TRENDS OF SECONDHAND SMOKE EXPOSURE?

Analysis of the National Health and Nutrition Examination Survey (NHANES) biomarker data from 2007–2008 indicates that approximately 88 million nonsmoking Americans, including both children and adults, are exposed to secondhand smoke.<sup>21</sup> Exposure among U.S. nonsmokers has declined substantially during the past two decades. The percentage of nonsmokers with detectable levels of cotinine fell from 88% in 1988–91 to 40% in 2007–2008 (Figure 3).<sup>21</sup>

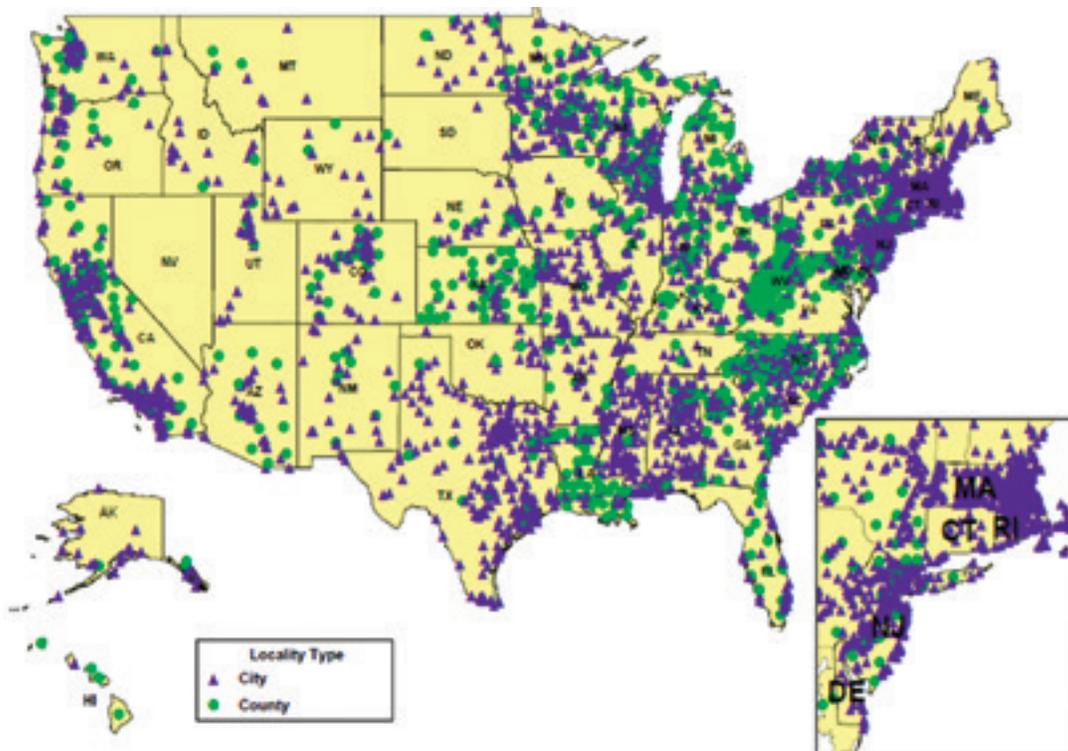
State-by-state data from the 2012 Behavioral Risk Factor Surveillance System (BRFSS) indicate that the adult prevalence of cigarette smoking varies considerably among states, ranging from about 11% to 28% of survey respondents. Smoking prevalence in 2012 was highest in Kentucky, West Virginia, and Arkansas and lowest in Utah, California, Hawaii, and Connecticut.<sup>22</sup> Generally speaking, the prevalence of secondhand smoke exposure would be expected to increase as the prevalence of smoking increases.

Survey data also suggest that secondhand smoke exposure indoors is declining. In 1993, 20.1% of homes with smokers prohibited smoking indoors. That prohibition increased to 47.2% in 1999.<sup>3</sup> Similar data for homes are not available on a national scale, but many states, counties, and cities have enacted legislation to ban smoking in certain public places (Figure 4). As of April 1, 2014, 60% of the states across the nation had laws that prohibit smoking in all restaurants, 28 states prohibited smoking in all workplaces, and 30 states prohibited smoking in all restau-

\* Through the National Biomonitoring Program (NBP), scientists at CDC's Environmental Health Laboratory determine which environmental chemicals individuals have been exposed to and how much of those chemicals actually get into their bodies. The NBP currently measures more than 300 environmental chemicals and nutritional indicators in people.<sup>20</sup>



**Figure 3.** Percentage of the nonsmoking population aged 3 years and above exposed to secondhand smoke, using the criterion of a serum cotinine level  $\geq 0.05$  ng/mL - National Health and Nutrition Examination Survey, United States, 1999—2008.<sup>21</sup>



**Figure 4.** U.S. cities and counties with laws as of April 1, 2014 that restrict smoking to any extent<sup>23</sup>

Note: American Indian and Alaska Native sovereign tribal laws are not reflected on this map.

\*\*\* Laws shown are those that restrict smoking to any extent. To see a map of 100% smokefree laws, please see United States 100% Smokefree Laws at [www.no-smoke.org/pdf/100Map.pdf](http://www.no-smoke.org/pdf/100Map.pdf)

rants and bars.<sup>23</sup> However, blue-collar, service, and hospitality workers were less likely than white-collar workers to be protected by smoke-free workplace policies. Other evidence suggests that African Americans are less likely than whites, Hispanics or Latinos, and Asian Americans to be protected by smoke-free home rules.<sup>3</sup> Note that these numbers are constantly changing as legislation is enacted or repealed.

## HOW CAN SECONDHAND SMOKE EXPOSURE BE PREVENTED?

Eliminating smoking in indoor spaces is the only way to fully protect nonsmokers from secondhand smoke exposure. Separating smokers from nonsmokers, cleaning the air, and ventilating buildings cannot be relied on to fully control health risks from secondhand smoke exposure.<sup>3</sup>

On an individual level, you can reduce your exposure to secondhand smoke by:

- Making your home and car completely smoke-free
- Asking people not to smoke in your presence
- Choosing restaurants and other businesses that are smoke-free

## ADDITIONAL RESOURCES

- CDC Surgeon General's Reports on Smoking and Tobacco Use [www.cdc.gov/tobacco/data\\_statistics/sgr/index.htm](http://www.cdc.gov/tobacco/data_statistics/sgr/index.htm)
- EPA Smoke-free Homes and Cars Program [www.epa.gov/smokefree/](http://www.epa.gov/smokefree/)

## RADON

### WHAT IS RADON?

Radon is a radioactive gas generated from the radioactive decay of uranium, a naturally occurring and pervasive element. Radon is odorless, tasteless, and invisible and is found throughout the United States. It seeps through building foundations and can also enter homes through well water. Many factors affect indoor radon concentrations. Soil radon levels vary geographically, and soil chemistry, porosity, moisture, and pressure gradients all influence the subsurface movement of radon into buildings and wells. Certain regions of the United States tend to have lower soil concentrations of radon overall than other regions, but radon levels still vary markedly from building to building within regions.

The average indoor radon concentration in U.S. homes is about 1.3 picocuries per liter of air (pCi/L). The EPA recommends that corrective action be taken if indoor concentrations equal or exceed 4 pCi/L.<sup>4</sup>

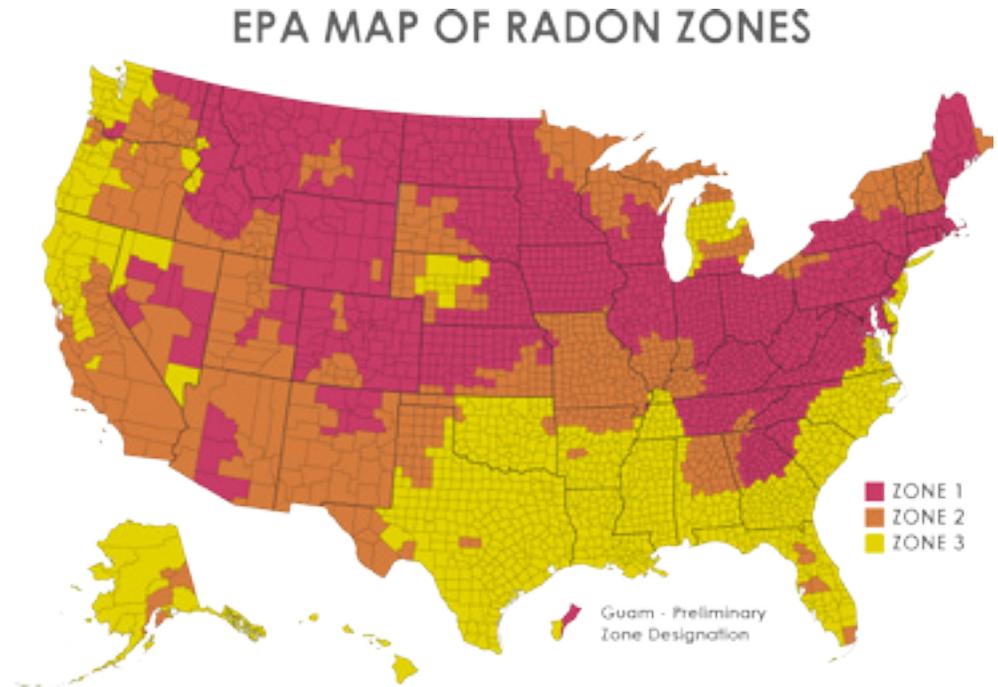
### WHAT ARE THE HEALTH EFFECTS OF RADON?

Radon is the second leading cause of lung cancer after smoking. Currently, the EPA estimates that 21,000 lung cancer deaths each year in the United States are radon-related. Of these deaths, about 2,900 occur among people who have never smoked. Radon is the number one cause of lung cancer among nonsmokers according to EPA estimates.<sup>4</sup>

Radon in drinking water also poses a health risk. Most of the risk arises from inhaling radon released from the water, but ingestion of radon in drinking water may pose a risk for stomach cancer.<sup>24</sup> The EPA estimates that radon in drinking water causes approximately 168 cancer deaths annually. Of these, 150 are from lung cancer caused by inhalation of radon released from water, and 18 are from stomach cancer caused by ingestion of radon-containing drinking water.<sup>25</sup>



**Figure 5.** Radon zones in the United States by county. Zone 1 – predicted indoor radon levels exceeding 4 pCi/L; Zone 2 – predicted indoor radon levels between 2 and 4 pCi/L; Zone 3 – predicted indoor radon concentrations less than 2 pCi/L<sup>25</sup>



## HOW ARE WE TRACKING RADON EXPOSURE IN THE HOME?

No national surveillance system exists for radon in indoor air or in drinking water. Because radon is not currently regulated in drinking water by the EPA, there is no requirement that public water utilities measure and report radon concentrations to state and federal regulators. However, the U.S. Geological Survey has conducted targeted studies of radon in groundwater and soils that are useful in estimating risks in specific geographical and geological areas. Additionally, some states have conducted extensive surveys of radon in indoor air in homes that are used to estimate the public health risk in specific geological areas.

Based on available data of 1) indoor radon measurements, 2) building foundation types, 3) geology, 4) soil permeability, and 5) aerial radioactivity measurements to assess the potential for elevated indoor radon concentrations, states and the EPA have published maps of radon potential. The EPA's map assigns each U.S. county to a zone indicative of its radon potential (Figure 5). The Rocky and Appalachian Mountain states, northern states, and the glaciated areas of the Great Plains have the most counties with elevated predicted indoor radon levels based on those five parameters used to determine indoor radon concentration potential. Note that predicted radon concentrations are not applicable to individual buildings; elevated radon concentrations can be found in all zones.

## HOW CAN RADON EXPOSURE BE PREVENTED?

The U.S. Surgeon General issued a health advisory in 2005 warning Americans about the serious health risk from exposure to radon in indoor air. Because millions of homes in the United States have an elevated radon level, the advisory urged people to test their homes every two years, and retest any time they move or make structural changes to their home. The advisory stressed the need to remedy the problem when the radon level is 4 pCi/L or higher.

Correcting the problem involves hiring a qualified radon mitigation contractor who will use one of several methods to reduce radon levels in your home. Attempting to reduce radon in your home without hiring a professional is not recommended because special skills and an understanding of radon movement are needed. A description of remedial measures is provided in an EPA brochure titled "Consumer's Guide to Radon Reduction," available at <http://www.epa.gov/radon/pdfs/consguid.pdf>.

## ADDITIONAL RESOURCES

- EPA Radon Home Page [www.epa.gov/radon/](http://www.epa.gov/radon/)
- American Lung Association: Radon [www.lungusa.org/healthy-air/home/resources/radon.html](http://www.lungusa.org/healthy-air/home/resources/radon.html)

## WHAT ARE AEROALLERGENS?

Aeroallergens are substances found in the air that induce a hypersensitive reaction in some people. The most common aeroallergens found in the home include:

- Pollen
- Mold
- Dust Mites
- Animal Dander
- Cockroach Allergen

### Pollen

Pollen from weeds, grasses, and trees has been linked with exacerbation of asthma symptoms, although pollen is not generally believed to be a risk factor for development of asthma.<sup>27</sup> The most important cause of seasonal allergic rhinitis (hay fever) is ragweed from the weed plant *Ambrosia*. Grass pollen ranks second only to ragweed in terms of the frequency and severity of allergic symptoms it causes in the United States.<sup>28</sup>

### Mold

Molds and mildews are types of fungi that can grow and exist in almost any environment, indoors and outdoors. Growth of molds and mildews vary according to humidity, temperature, barometric pressure, and nutrient source. People can be allergic to the actual fungal form or the spores released by fungi for reproduction. Molds typically found indoors and outdoors in all regions and all climates in the United States are *Aspergillus*, *Cladosporium*, and *Penicillium*.<sup>29</sup>

People who are allergic to mold might exhibit symptoms, such as a stuffy nose, eye irritation, and wheezing, when exposed. Asthma attacks can occur in people with both asthma and mold allergies. The outdoor fungal spore *Alternaria* is known to aggravate asthma<sup>28</sup> and is also a known risk factor in the development of asthma.<sup>30</sup> Both mold-allergic and nonallergic people may experience irritation of the eyes, skin, nose, throat, and lungs when exposed to mold.

### Cockroaches

Cockroach allergen is believed to derive from the feces, saliva, and bodies of these insects. Cockroach allergen is a primary trigger of asthma symptoms, especially for children living in densely populated, urban neighborhoods. It also may play a role in the development of asthma in some children.<sup>31</sup>

### Dust Mites

House dust is home to microscopic creatures called house dust mites. Their droppings are the most common trigger of perennial allergy and asthma symptoms.<sup>32</sup> Dust mites are found throughout the house, but they especially thrive in high humidity and in areas where human dander (dead skin flakes) is located. Dust mite allergen is a known risk factor for the development of asthma in some children.<sup>31</sup>

### Animal Dander (cat and dog)

Animal allergen is a protein found in the saliva, dander, or urine of furred animals. These proteins, which are carried through the air on microscopic particles, can irritate the lining of the eyes, nose, and lungs. All cat and dog breeds are capable of triggering symptoms—no breeds are hypoallergenic.<sup>33</sup>

## WHAT ARE THE HEALTH EFFECTS OF AEROALLERGENS?

Exposure to aeroallergens is known to be a major environmental risk factor in the development of asthma in children and may play a role in the observed increase over the past 25 years in the prevalence and severity of asthma in children. Aeroallergens can also cause or exacerbate other diseases affecting the respiratory tract (rhinitis and sinusitis), the skin (eczema or hives), and the eyes (allergic conjunctivitis).

## HOW ARE WE TRACKING AEROALLERGENS IN THE HOME?

Outdoor concentrations of pollen and mold are routinely monitored by the National Allergy Bureau (NAB), part of the Aeroallergen Network of the American Academy of Allergy, Asthma, and Immunology (AAAAI). However, the presence and concentrations of aeroallergens inside homes are not routinely monitored or tracked. Data about the types and quantities of certain aeroallergens in the home are derived from surveys of a representative sample of homes, at a specific interval of time, which may be used to estimate national rates of exposure

to allergens. For example, the NSLAH, described previously in the lead section, included sampling for allergens and bacterial endotoxins (toxins secreted by microorganisms and released into the surrounding environment only when they die).

## STATUS AND TRENDS FOR AEROALLERGENS

Studies have demonstrated that allergens from cockroaches, dust mites, animal dander, and indoor molds can be found year-round throughout the home and at different levels depending on the socioeconomic status of the household.<sup>28,32,33,34</sup> In one study conducted in homes of asthmatic children in the northeastern United States, researchers found concentrations of cockroach, dust mite, and animal allergen in 86% of homes tested. The NSLAH study documented detectable cockroach allergen in 63% of the homes tested, with the highest prevalence of elevated concentrations found in high-rise apartments, urban areas, pre-1940 buildings, and low income households.<sup>35</sup>

Indoor mold aeroallergen derives primarily from airborne outdoor mold. Indoor mold spore concentrations are usually lower than outdoor concentrations. A study of airborne fungal concentrations in 1,717 buildings located across the United States found that both outdoor and indoor fungal concentrations were highest in the summer and fall and lowest in the winter and spring. Indoor mold allergen concentrations were highest in the southern United States and lowest in the Northeast. No significant year-to-year variation in the indoor fungal concentrations was observed.<sup>30</sup>

## HOW CAN EXPOSURE TO AEROALLERGENS BE PREVENTED?

Aeroallergens are difficult to avoid completely. However, you can take measures to minimize your exposure and help reduce the concentrations of aeroallergens in your home.

### Cockroaches

- Keep your home clean and dry. Cockroaches thrive in high humidity and need food and water to survive. Put food in sealed containers or in the refrigerator and keep countertops and floors clean. Fix leaky faucets or pipes.

- Put pet food dishes away after your pet is done eating.

### Dust Mites

- Wash bedding weekly to kill mites and remove mite allergens. Dust mites favor bedding, including pillows and stuffed animals.
- Vacuum weekly, especially if you have carpets.

### Animal Dander

- Keep your pet outside, if possible. Indoor pets should be confined to rooms that are not used by the person who is sensitive to animal dander. Vacuuming may be helpful in reducing animal allergen exposure.
- Bathe your cat or dog twice weekly. This may help, but saliva is also a source of allergen. Urine is the allergen source for rabbits, guinea pigs, and hamsters.

### Molds

- Decrease indoor humidity, if possible. Ventilate bathrooms and kitchens, and repair leaky faucets.
- Remove any visible mold. For example, use a dilute bleach solution to wipe down windowsills or bathroom areas where mold or mildew is growing.

## ADDITIONAL RESOURCES

- CDC Indoor Air Quality Information [www.cdc.gov/nceh/airpollution/indoor\\_air.htm](http://www.cdc.gov/nceh/airpollution/indoor_air.htm)
- EPA Mold home page [www.epa.gov/mold/moldguide.html](http://www.epa.gov/mold/moldguide.html)
- EPA Indoor Air Quality [www.epa.gov/iaq/](http://www.epa.gov/iaq/)



## VOLATILE ORGANIC COMPOUNDS (VOCs)

### WHAT ARE VOLATILE ORGANIC COMPOUNDS (VOCs)?

Volatile organic compounds (VOCs) are a group of organic chemicals that are emitted as gases from certain solids or liquids at normal room temperatures. VOCs include a variety of chemicals and are present both indoors and outdoors, but indoor concentrations of many VOCs have been found to be higher (up to ten times higher) than outdoor concentrations. VOCs are emitted by a wide variety of products numbering in the thousands.<sup>36</sup>

Some of the VOCs commonly found in homes include toluene, styrene, xylene, dichlorobenzene, trichloroethylene, formaldehyde, and other aldehydes. Tobacco smoke is a significant source of indoor VOC exposure<sup>37</sup> (see earlier section on secondhand tobacco smoke). Common household items that can release these VOCs include the following:<sup>36</sup>

- Air fresheners
- Paint
- Varnish
- Wax
- Cleaning and disinfecting agents
- Cosmetics
- Degreasers
- Products containing particle board and plywood
- Carpeting
- Glues
- Permanent markers
- Dry-cleaned clothing
- Hobby products

### WHAT ARE THE HEALTH EFFECTS OF VOCs?

The health effects of VOCs are varied and depend on the specific compound. As with other pollutants, the extent and nature of the health effect will depend on many factors, including level of exposure and length of time exposed. At present, not much is known about what health effects occur from the levels of organic chemicals usually found in homes. Elevated indoor concentrations of VOC mixtures may play a role in the collection of symptoms known as “building-related symptoms” (e.g., headaches;

fatigue, eye, nose, and throat irritation). The range of health effects from VOC exposure includes those mentioned above as well as wheezing, asthma attacks, dizziness, visual disorders, and memory impairment. Many organic compounds are known to cause cancer in animals; some are suspected of causing, or are known to cause, cancer in humans.<sup>36</sup> At elevated levels, levels not normally found in the home environment, exposure to VOCs can cause death.

Formaldehyde is a component of building materials and is found in high levels in many new buildings although the level decreases over time. Airborne concentrations of formaldehyde at levels above 0.1 ppm (parts per million) can cause watery eyes; burning sensations in the eyes, nose and throat; nausea; coughing; chest tightness; wheezing; skin rashes; and allergic reactions. Formaldehyde also has been observed to cause cancer in laboratory animals and is a probable human carcinogen.<sup>38</sup>

Formaldehyde is normally present at low levels in indoor air, usually less than 0.03 ppm. Residences or offices that contain products that release formaldehyde in the air can have formaldehyde levels of greater than 0.03 ppm. Products that may add formaldehyde to the air include particleboard used as flooring underlayment, shelving, furniture and cabinets; fiberboard used in cabinets and furniture; hardwood plywood wall panels; and urea formaldehyde foam used as insulation. As formaldehyde levels increase, illness or discomfort is more likely to occur and can be more serious.<sup>38</sup>

### HOW ARE WE TRACKING VOCs IN THE HOME?

The presence and concentrations of VOCs indoors are not tracked directly but have been examined through surveys and research studies related to VOC exposures. For example, a small sample population of the CDC’s National Health and Nutrition Examination Survey (NHANES) III, conducted from 1988–1994, participated in a follow-up study on VOCs. These participants, who were not exposed to VOCs through work, had their blood samples analyzed for 32 VOCs. They also completed a questionnaire about exposure to various chemical products.<sup>41</sup>

In the early to mid-1980s, prior to NHANES III, the EPA analyzed indoor and outdoor concentrations of up to 25 VOCs in the homes and yards of 650

persons.<sup>42</sup> VOC concentrations in urine, blood, and exhaled breath were also measured to estimate how exposure to VOCs was affecting the health of the individuals.<sup>42</sup> The project was conducted in four states. Analyses were repeated at different times of the year in some locations. The analysis done in both the NHANES and the EPA studies did not include detection for formaldehyde.

CDC measured exposure to 29 VOCs from selected participants of NHANES 2005–2006. These biomonitoring results were reported in the Fourth National Report on Human Exposure to Environmental Chemicals and then updated in the Fourth National Report on Human Exposure to Environmental Chemicals, Updated Tables, July 2014.<sup>43</sup> While NHANES data is important to tracking indoor VOC exposure, its results do not tell us when or where exposures occur. This limits our understanding of exposure trends and the creation of new prevention strategies.

## WHAT ARE THE STATUS AND TRENDS FOR VOCs

Research by the EPA in the mid-1980s demonstrated that almost all of the VOCs studied had higher concentrations indoors than outdoors, sometimes as much as ten times higher.<sup>36</sup> This was observed in rural as well as highly industrialized areas. The presence or absence of indoor sources of VOCs was a much stronger determinant of indoor air concentrations than how well the home was ventilated (the air exchange rate). The particular VOCs detected also varied with the seasons and with geographic location.

Of the 29 VOCs included in the CDC's NHANES study, 8 were detectable in more than 75% of the sample population's blood. These included benzene, ethylbenzene, styrene, toluene, and xylene, which the researchers attributed to tobacco smoke and emissions from internal combustion engines.<sup>44</sup> Vehicle exhaust in attached garages migrates into homes and has been shown to account for most of the combustion-related VOCs found in the homes of nonsmokers.<sup>45</sup> The NHANES study also reported that dichlorobenzene, found in air fresheners, toilet bowl deodorants, and mothballs, was detected in almost all of the sample population. Dichlorobenzene has been associated with reduced pulmonary function. Trihalomethanes were detected in at least

10% of the sample population and water disinfection is a possible source.<sup>44,47</sup>

## HOW CAN WE PREVENT VOC EXPOSURE?

Sources of VOCs are found throughout the home. Some, like furnaces and carpeting, cannot be readily removed. However, you can still reduce your exposure by taking these steps:

- Ventilate your work area as much as possible when using VOC-emitting products, such as paint, varnish, adhesives, and degreasers. Use the products outside or use indoors near an open window or exhaust fan.
- Avoid storing VOC-emitting products indoors. Buy only as much paint or varnish, for example, as you plan to use soon to avoid long-term storage. Properly discard unneeded chemicals or nearly empty containers of products that release VOCs.
- Keep the door between an attached garage and the house closed as much as possible to minimize the flow of vehicle exhaust and other VOCs from stored fuels and paint supplies into the house.
- Insist that the dry cleaner remove the odor before you take the items home if your dry-cleaned items have a strong chemical odor when you pick them up. Dry-cleaned items that have been properly dried should not have a strong chemical odor.
- Use your stove's exhaust fan when cooking.
- Prohibit smoking inside your home.



## ADDITIONAL RESOURCES

- CDC Indoor Environmental Quality  
[www.cdc.gov/niosh/topics/indoorenv/ChemicalsOdors.html](http://www.cdc.gov/niosh/topics/indoorenv/ChemicalsOdors.html)
- EPA Volatile Organic Compounds  
[www.epa.gov/iaq/voc.html](http://www.epa.gov/iaq/voc.html)

## PESTICIDES

### WHAT ARE PESTICIDES?

Pesticides are any agent used to control pests, such as insects, rodents, weeds, fungi, and bacteria. They can remain in a home for years after use has stopped and have been found in indoor air, carpet dust, and on settled dust surfaces. They are a particular concern for low income, inner-city neighborhoods where pest infestations (e.g., cockroaches, mice, and rats) are common.<sup>51,52</sup> Exposure

to pesticides occurs through diet and skin absorption and through inhalation of airborne pesticides, either as an aerosol or absorbed on dust particles.<sup>53</sup> In 2010, EPA estimated that 75 % of U.S. households used at least one pesticide indoors during the past year, and that 80 % of most people's exposure to pesticides occurred indoors.<sup>5</sup>

### WHAT ARE THE HEALTH EFFECTS OF PESTICIDES?

Chronic pesticide exposure can result in attention and behavioral problems, damage to the liver and kidneys, nervous and endocrine systems damage, and increase the risk of cancer.<sup>54,55,56,57</sup> Pyrethroid pesticides, the most common type of over-the-counter pesticide, may be toxic to multiple systems within the body. These pesticides can damage, destroy, or impair the function of the immune system, the neurological

## Imported Drywall and Health <sup>48</sup>

Drywall from China was imported into the U.S. from 2006 to 2008 to address the shortage of construction materials created by the 2004 and 2005 hurricane seasons and the national demand for new home construction. Beginning about 2008, people living in homes built between 2001 and 2008 began reporting health issues. People also reported corrosion of certain metal components in their homes.

A 2012 U.S. Department of Housing and Urban Development (HUD) report estimates that problem drywall imported from China was most likely used in the construction of approximately 11,000 new homes. As of May 2014, the U.S. Consumer Product Safety Commission (CPSC) received more than 4,051 reports from residents in 44 states and the District of Columbia, American Samoa and Puerto Rico regarding the presence of problem drywall in their homes.<sup>49</sup>

The CPSC, the EPA, the CDC, the Agency for Toxic Substances and Disease Registry (ATSDR), and state health departments, jointly investigated this issue. The agencies worked to identify whether the drywall emitted chemicals of concern and whether homes containing the drywall posed any health risk to people who lived in them.

On May 2, 2014 ATSDR released a Health Consultation Report on the possible health impacts from exposure to sulfur gases emitted from Chinese-manufactured drywall.<sup>50</sup>

Based on the laboratory tests and modeling of hydrogen sulfide and other sulfur compounds emitted from samples of drywall manufactured in China in 2005 and 2006, ATSDR concluded that people who were exposed to such drywall may have experienced adverse health effects. Because of the small number of drywall samples tested, the findings cannot be generalized to all problem drywall.

Health symptoms associated with exposures to sulfur compounds:

- Exacerbation of pre-existing respiratory conditions (e.g. asthma)
- Eye and nasal irritation,
- Headache,
- Changes in vision, and
- Weakness.

Additionally, odors associated with sulfur compounds may disrupt daily activities or cause stress.

system and the endocrine system which can result in endocrine disruption in humans and other mammals.<sup>58</sup> Inert (inactive) ingredients, not typically included in risk assessments, are also potentially hazardous and might contribute to the effects from the active ingredients.<sup>59,60</sup> Because many pesticides target the nervous system, the risk from exposure to multiple pesticides can be cumulative.

## HOW ARE WE TRACKING PESTICIDE EXPOSURES IN THE HOME?

Several national pesticide surveillance systems exist, but none collects all of the information needed to quantify chronic pesticide exposure in the home. The chapter on poisoning provides a detailed discussion of unintentional pesticide poisonings. The National Poison Data System (NPDS) of the American Association of Poison Control Centers is a national, real-time surveillance database that includes all human exposures reported to participating U.S. poison control centers since 1985.<sup>61</sup> Acute pesticide exposure cases are managed and entered into the NPDS by poison information specialists at each U.S. poison control center. The type of pesticide and location of exposure are usually reported, but NPDS lacks information on chronic exposure, and underreporting is strongly suspected.

The CDC's NHANES collects pesticide exposure data not only via questionnaire but also from biomonitoring for some common pesticides and their metabolites.<sup>43</sup> The source and location of the pesticide exposure are not determined and may include occupational or other sources outside the home. Also, biomonitoring does not necessarily detect chronic exposures.

In the 1990s, the EPA collected data in several areas of the United States in their National Human Exposure Assessment Survey (NHEXAS). Using questionnaires about home pesticide use and measurements of pesticides in the home environment, NHEXAS focused on the exposure of people to environmental pollutants in their daily lives. Hundreds of subjects were randomly selected from several areas of the country and asked to participate. Researchers measured the levels of chemicals in the air that participants breathe; in food, drinking water,

and other beverages; and in the soil and dust around their homes. Measurements were also made of chemicals in biological samples (including blood and urine) provided by some participants.<sup>62</sup>

## WHAT ARE THE STATUS AND TRENDS FOR PESTICIDES

On the basis of NPDS data collected in 2010–2012, exposures to pyrethroids (insecticides), rodenticides (rodent pest control chemicals), borates and/or boric acid pesticides, DEET (common ingredient in pest repellants) and glyphosates accounted for the five most reported pesticide exposures.<sup>61</sup> During that time interval, 41%–43% of all pesticides exposures reported occurred in children under 6 years old. Exposures to pyrethroids, rodenticides, DEET and glyphosates decreased during that time period, while exposures to borates and/or boric acid pesticides increased.<sup>61,63,64</sup>

Between the 1999–2000 and 2001–2002 NHANES surveys, biomonitoring documented a downward trend for exposure to two organophosphate pesticides, possibly reflecting the reduction or phasing out of some uses of these types of pesticides.<sup>43</sup> Biomonitoring results from the 2003–2004 NHANES showed levels similar to those of previous survey periods, lower than the levels found in some studies in other countries, and much lower than levels seen in workers who used organophosphorus insecticides.<sup>43</sup>

The EPA NHEXAS study found that chlorpyrifos, pyrethrin, and permethrin were commonly found in homes. Chlorpyrifos was detected in 92.5 % of indoor air samples and was also found in carpet dust, soil, and food samples.<sup>62</sup> Residential use of this pesticide is now prohibited.

Environmental public health tracking programs implemented in New York City and some states (California, Wisconsin, and others) collect limited data on pesticide exposure. In New York City, pesticide use and infestation patterns were found to differ depending on socioeconomic status and demographic factors. Using data from the Community Health Survey, the New York City Department of Health and Mental Hygiene mapped the use of pesticide sprays, bombs, and foggers (Figure 6). They observed that low-income families were more likely to use these products than were families with higher incomes.<sup>65</sup>

## HOW CAN WE PREVENT PESTICIDE EXPOSURE?

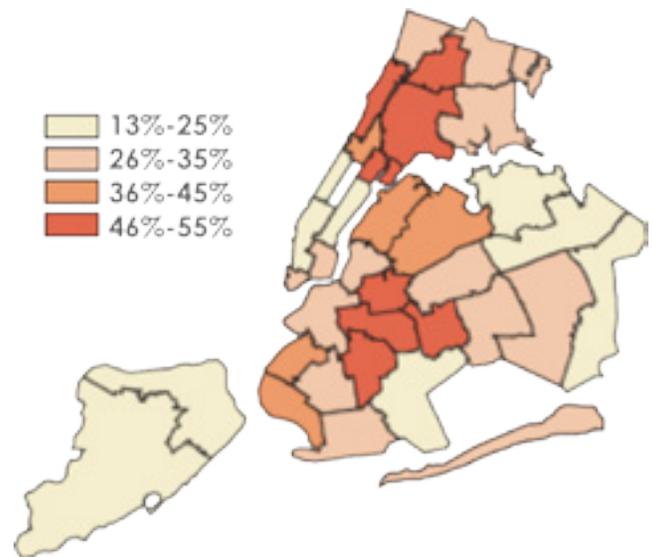
If you use pesticides, carefully follow the manufacturer's instructions. Mix or dilute the pesticide outdoors or in a room with good ventilation. Do not store unneeded pesticides in the home. A safer alternative to using chemical pesticides is to take steps that make your home less attractive to pests:

- Do not leave food, pet food, or garbage where pests can eat it. Store food in sealed containers or in the refrigerator, remove garbage daily, and put pet food away in a sealed container.
- Remove water sources that pests use. Fix leaks and dripping faucets, and keep sinks, showers, and bathtubs dry overnight.
- Reduce clutter, especially piled newspapers or cardboard. Seal holes and cracks with caulk or plaster.

If pests persist, use only safer pest-control products like boric acid, gels, and baits for cockroaches, and glue traps or baited traps for rodents. Avoid bombs, foggers, and sprays.

## ADDITIONAL RESOURCES

- CDC Pesticide Illness & Injury Surveillance  
[www.cdc.gov/niosh/topics/pesticides/Statebase.html](http://www.cdc.gov/niosh/topics/pesticides/Statebase.html)
- EPA Pesticides  
[www.epa.gov/pesticides/index.htm](http://www.epa.gov/pesticides/index.htm)



**Figure 6.** Percent of households in New York City that use pesticide sprays, bombs, or foggers. Pesticide use is most common in Northern Manhattan, Southern and Central Bronx, and Central Brooklyn<sup>65</sup>

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